Method and device for the uncoverage and the local enclosure of unwanted radio transmissions

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Description

The invention refers to a method and a device for the uncoverage and the local enclosure of unwanted radio transmissions, for example unwanted telephony with mobile radiotelephones, according to the precharacterising part of claim 1.

Radio transmissions are not permissible in all spheres of life. Examples for unallowed spheres are jails (because of safety against unallowed agreements and so on), but also aircrafts, hospitals (each because of electromagnetic compatibility EMC) or other spheres (defense of disturbance as for example in restaurants or the like). In theses spheres a unallowed radio transmission must be recognized reliably and sufficiently locally assigned, so that a drafty turning off of the device und perhaps a taking away is possible. For this instance the device must by no means be conceived as a radio set. Also a lot of other devices, such as so-called notebooks and CD-players, disturbe because of the therein used high clock frequencies.

Mobile radiotelephones (for example so called "cellular phones") send out during telephoning and during organizational processes (for example checking in in a cellular net) high frequency energy. The respective radio network (for example GSM, DECT, Tetra) shows their characteristic features in the tuning area and in the time domain, through which the radio transmission can be assigned. Other devices (see above) send out as an undesired side effect high frequency energy with characteristic features.

A first group of known devices for recognizing unwanted radio transmissions reacts to radio transmissions in an interesting tuning area by means of an acoustical/ optical/ electrical alarm. Higher-classed, especially for radiotelephones conceived devices analyse the radio transmissions for further characteristics (for example in the time domain) for minimizing spurious alarms (for example "Mobifinder" of the german company MAZ, published in the german magazine VfS (Verband für Sicherheitstechnik), Fachinformation 2/98, pages 8-11).

These devices show the drawback to search for relay line sections in the surrounding area regardless of the direction. The size of the scanned area depends on the sensitivity of the reciever, the transmitted energy (which can vary very much in modern transmission systems, because it may be adaptively adjusted) and on the propagation of waves, which is very complex and little predictable. Therefore an alarm is locally such unspecific, that a localisation of the device emitting high frequency radiation after triggering an alarm is very difficult. On the other hand, quite a lot of devices with a very small recieving area must be used, which is difficult to insure in the view of radio technology an economically dubious.

A second group of devices, again especially for mobile radiotelephones, disturbs the organisational channel of the respective network (for example devices of the company Netline, device C-Guard Cellular firewall), so that there isn´t possible any log in. As a further idea the simulation of a base station exists for detecting possible mobile radiotelephones by inquiry in a limited area.

These devices are developed especially for mobile radiotelephones and destroy respectively influence the possibility for having a telephone call by interfering the existing networks. Because a lot of buildings/areas to be protected are settled in build up areas, such a solution will not be accepted by the operating company. After all outside of the guarded buildings or the same telephony shall be possible undisturbed.

An exact radio-engineered limitation of the area isn´t practically possible due to the properties of the spreading of radio transmissions.

Another group of devices are radiogoniometer (for example Rhode und Schwarz, digital direction finding device DDF0xS). They make it possible in an undisturbed relay line section without multiple way reception to determine the direction, from which a radio transmission (als wanted or as side effect) comes.

Radiogoniometry is a well known method for localisation of radio transmitters. But it will only works correct in an area with undisturbed spreading (free field). Furthermore it is only possible via costly additional procedures, in addition to direction measuring to carry out a distance measuring (and therefore an exact measuring on the spot).

For the described application it isn´t possible to start from the fact of an undisturbed spreading. Rather modern radio transmission systems (especially in higher regions of frequency, for example GSM, DECT, Tetra) depend on the utilization of reflec-

tions, diffraction and so on. Generally high frequency emitting devices are located in build up areas, in buildings or airplanes and so on with the effect of multiple way reception. Therefore it is possible that an radio transmitting device is located in a totally different direction as the result of the radiogoniometry (published for example in "Proceedings of the 8th IEEE Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC 97), page 95-99). A radiogoniometry alone doesn't therefore meet the requirements.

Last but not least there are devices known, which measure the location of a high frequency emitting device by means of runtimes (company Cell-Loc. Inc./ device Cellocate). These devices are still rather inaccurate (accuracy is stated to be at 125 m in 67% of the measurements).

The localisation solely by means of runtimes is still to inaccurate and in any case problematically in the case of multiple way reception.

Because of this at the moment there is no solution available, that makes possible a fast and localized measurement of an unwanted radio transmission without huge effort of measurement and personal.

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Object of this invention is therefore to make possible a fast and locally specified measurement of unwanted radio transmissions.

The solution of the object according to the invention results with respect to the procedure from the characterising features of claim 1 in accordance with the features of the pre-characterising part as well as with respect to the device from the features of claim 24. Further advantageous embodiments of the invention result from the dependent claims.

This invention depends on a method for the uncoverage and the local enclosure of unwanted radio transmissions, for example unwanted telephony with mobile radiotelephones, in which with at least one radio receiver with an antenna, which can be influenced in respect of the receiving properties of the antenna, examines a surrounding area of the radio receiver for the existence of radio transmissions. Such a method will be improved in that way, that as a starting point at least one initial training phase is carried out, during which by means of changing locally allocation between a reference emitting device for radio transmissions and the radio receiver representations of emitted and locally known reference radio transmissions are recorded. These representations picked up during the initial training phase allow an allocation of the local position of the reference radio

transmissions transmitting reference emitting device, which during the later procedure of the method make possible a comparison between radio transmissions not emitted by the reference emitting device and those of the reference emitting device. Therefore at least one measurement phase is carried out, during which the surrounding area is scanned by the radio receiver for the existence of unwanted radio transmissions and by recognition of unwanted radio transmissions a representation of the unwanted radio transmissions is determined. This scanning and recording of the representation of the unwanted radio transmissions serves on the first hand for determining the existence of unwanted radio transmissions and on the other hand by usage of the representation of the unwanted radio transmissions in a later step of the method in an evaluation phase for the comparison between the representations taken up in the initial training phase and the representation of the unwanted radio transmissions and determining thereof it an information of the local position of the unwanted radio transmission in the surrounding area. By the comparison of the representation of the unwanted radio transmission and the representation of the reference radio transmissions it is possible to conclude by different criteria, which of the representations of the reference radio transmissions comes closest to the unwanted radio transmission and to make a statement, where the emitting device of the unwanted radio transmission will probably be located. Herewith in this application as representation of the reference radio transmissions respectively of the unwanted radio transmissions all three-dimensional and/or in time dissolved physical characteristic quantities or signals shall be understood, which can allow any statement about the radio transmissions. Herewith such representations can be constituted for example from any characteristic quantities for the radio transmissions, which can for example be obtained by a receiver device as the characteristic quantities power, frequency respectively modulation or of course every other characteristic quantity known in high-frequency engineering. So it is possible to depict the signal amplitude of the radio transmissions in correlation to the azimuth and perhaps in correlation to the elevation. The term representation of the radio transmissions shows not only these obvious contents of term, but it is also explicitly indicated, as still shown for different preferable embodiments, that for the support of the locally enclosure further features of the signals, for example features in time as signal runtimes and so on can also be brought in for evaluation of the term representation of the radio transmissions.

The novel method therefore is structured in an initial training phase, two measuring phases and the evaluation. In the initial training phase the whole receiving area is scanned (fast) by pivoting the directional antenna for finding unwanted radio transmissions. Because in the interesting area no radio transmissions (of the checked kind) are allowed, the hit frequency is rather small. Has a radio transmission been found, as a rule only one device is involved. It is possible in one preferably embodiment to screen the radio transmission of this device in a second measuring phase with the solution of the directional antenna. Hereby evolves an one-dimensional or two-dimensional representation of the unwanted radio transmission. The features of this representation give information for the local position of the device. Therefore in an initial training phase a representation of each room/ interesting area was taken up (that means the one-dimensional/two-dimensional representation of the radio transmission for a device of the checked kind in this area). Because the arrangement of the rooms/ interesting areas generally not changes, it is possible to find a correlation preferably with the methods of image analysis/ pattern recognition. This correlation will own a certain degree of reliability.

Therefore a radio receiver can be used, which has at his disposal a directional antenna, in which the directive efficiency is controllable about the whole or at least a part of the total ball surface surrounding the receiving device. The three-dimensional resolution of the receiving device is also influencable. As a method therefore it is possible to swivel the receiving lobe or to swivel the receiving minimum or the use of another method of radiogoniometrical techniques. Also it may be possible, that the the change of the directive efficiency of the receiving device is carried out mechanically or electrically or by another known method.

For carrying out the comparison of the representations of the reference radio transmissions coming from the initial training phase with the representation of the unwanted radio transmission if an unwanted radio transmission is acknowledged the measuring signals are in further development transmitted during a secondary measuring phase to an evaluation device, in which the measuring signals are evaluated to an one-dimensional or a two-dimensional representation of the radio transmission. In this evaluation device in a preferably embodiment the representation of the unwanted radio transmission and the representations recorded during initial training phase are compared with each other for correspondences, in which in a preferably embodiment the comparison is carried out

by methods of pattern recognition and/or image analysis. Such methods are well known for the expert and shall therefore not be explained in detail. It shall be called attention to the fact, that also methods of fuzzy techniques can be taken into consideration.

In a preferably embodiment it is an objective of the comparison, that the representation recorded in the initial training phase, which comes closest to the representation of the radio transmission, as well as the local position of the reference radio transmission known by the initial training phase are used as information for the local position of the emitting device of the unwanted radio transmission in the surrounding area. Therefore the representation of the reference radio transmission coming closest to the representation of the unwanted radio transmission is elected and the corresponding information about the local position of the reference radio emitting device during the recording of the reference radio transmission is taken as a probable position also for the emitting device of the unwanted radio transmission. Such an evaluation can use in a preferably embodiment also additional information coming from the representation, as for example time features, signal runtimes, time offset while channel switching or the like. In this way the distance can be roughly estimated for e.g. cellular phones by the time offset between the organisational channel of the involved base station and the radiation of the radio emitting device. Hereby a further dimension can be fit in the method for pattern recognition. By means of further characteristic quantities the pattern recognition can be transferred to a n-dimensional method of evaluation.

In case of detecting of an unwanted radio transmission and if the local position of the unwanted radio transmission can be determined by this evaluation method an alarm is released and operating personnel or the like can well-aimed search in the determined three-dimensional areas for the existence and the owner of an emitting device and stop the usage. Hereby in a preferably embodiment it is possible that while determining radio transmissions in areas, which are surveyed, but in which radio transmission is principally allowed (e.g. outside of the surveyed area), such an alarm is suppressed from the beginning, so that an alarming of the operating personnel happens only if probably an emitting device is located within the surveying area in inadmissible areas.

In the non probable case of recognising multiple simultaneous radio transmissions by a special treatment during evaluation a result can also be achieved (even though not such a good). The overlay areas outside the guarded area, in which a radio transmission is

allowed and which can't be avoided because of radio-engineering restrictions, belong also to the interesting areas. Is the device located in these areas, no (spurious) alarm is triggered.

For supporting the local determination additional features of the signal (e.g. features of time) are usable. In this way the distance can be roughly estimated for e.g. cellular phones by the time offset between the organisational channel of the involved base station and the radiation of the radio emitting device. Hereby a further dimension can be fit in the method for pattern recognition. By means of further characteristic quantities the pattern recognition can be transferred to a n-dimensional method of evaluation.

As methods of pattern recognition fuzzy techniques can be employed, because the problem of measuring is per se "blurred".

The (measuring) receiver can be moved on a known path. During this path the patterns of the respective position of receiving are used.

The results can be improved by means of several receiving configurations (a plurality of receivers or diversity receiving) and a common evaluation.

By means of a respective sensitive measuring receiver (this is supported by the directive efficiency of the antenna) for the special case radiotelephony so-called cellular phones can be located, which work solely in the so-called stand-by mode. In this case the different signal/frequency structure can be taken into consideration. Cellular phones in the so-called stand-by mode are often clock-pulsed in respect of their reception state for extending the duration of the usage time of their accumulators. The signal of the clock-pulse controlled switching online or offline the receivers can also be used.

By means of a respective sensitive measuring receiver (this is supported by the directive efficiency of the antenna) for the special case of determining unwanted radio transmissions of devices not conceived therefore (so-called notebooks, CD-players or the same) also their poor emission can also be registered and locally determined.

Using the described method it is possible for the first time to locally determine unwanted radio transmissions within an observation area relatively exact and at favourable conditions. This is possible despite of the multiple way transmission in the described applications. Such a tracking down assumed by this time a measuring with a lot of personnel with special measuring devices and making conclusions by trained experts in radio transmissions. Because of the initial training phase the necessity of experts exists – even at all – only during the initial train-

ing phase. After this the device can be handled by semi-skilled personnel coming from the respective institution, which will be surveyed. Therefore a surveillance is possible around the clock at very favourable conditions.

By means of the nowadays very efficient digital techniques the algorithm of pattern recognition can be carried out on a standard computer. Electronically adjustable antennas get a mass product because of their arising usage in radio telephony networks and get also cheaper. The same counts for HF receiver. Therefore it is possible to save costs for personnel and also to base on acceptable costs for the devices. Enbodiments for the application of the novel method are shown in the figures and are described in the following passages.

Very preferable applications according to the inventive method and the device show the figures:

Fig. 1 - surveillance of a building from outside (jail),
Fig. 2 - surveillance of an airplane,
Fig. 3 - surveillance of a building from inside (hospital).

In the application of the example according to figure 1 the front side 1 of a building of a jail is kept under surveillance by means of a single measuring receiver 2. The reciever 2 stores during an initial training phase for each cell 3 that pattern/those patterns, which arise during carrying out telephony inside of this cell 3. By means of pattern recognition it is possible to recognise this pattern for example in cell 6 during unallowed usage of a cellular phone and determining this pattern with a certain probability to this cell 6. Hereby multi way receiving (indicated by the two arrows 4 respective 5) must be dealt with.

An allowed radio telephony 7 outside the building 1 can because of reflections at the front side of the building 1 of the jail result in a radio receipt corresponding to the way of the signal 5 from the direction of the jail. Because of obstacles 8 (e.g. trees with leaves) the direct path between cellular phone of the allowed radio transmission 7 and receiver 2 (line of sight) can be blocked. A simple method for direction finding would cause wrong results. The two-dimensional pattern of the reflected radio transmission 4 differs however from the patterns of the radio transmissions 5 coming from cell 3. Therefore the allowed radio transmission 7 can be recognized as such and no alarm will be triggered.

Because of seasonal changes in the surrounding (e.g. because of leaves of trees) in this constellation a seasonal conditioned training phase for the patterns would be used. Also a new initial training phase in suitable time steps could be inserted.

After recognizing an unallowed radio transmission the personnel of the jail can purposeful search for the emitting device in the cell 3/in the cells 3 because of the local determination.

In the application of the example according to figure 2 an airplane is kept under surveillance by means of a two measuring receivers 2, 9. The receivers 2, 9 store during an initial training phase for every seat 13 respective every row of seats 10 that pattern/those patterns resulted by radio transmission coming from there. Hereby the patterns must generally be stored in respect of the frequency. This is necessary, because in the airplane the unwanted radio transmissions 12 coming from devices (cellular phones in stand-by mode, notebooks and so on) can vary in a wide frequency band. By means of pattern recognition it is possible to recognise this pattern during a unallowed radio transmission 12 and to determine this pattern with a certain probability to a certain row 10 of seats/ a certain seat 13. In this example two receivers 2, 9 are used for purposes of improving sensitivity and resolution of local position. Hereby multi way receiving (indicated by the arrows 12) must be dealt with.

Because of slight changes of the surrounding in accordance to the reservation of every flight the pattern recognition must act flexible, e.g. by using fuzzy techniques.

After recognizing an unallowed radio transmission 12 the cabin personnel can purposeful search/ask for the device after the local determination (hatched area 14).

In the application of the example according to figure 3 an area 16 to protect within a building (here e.g. a hospital) is kept under surveillance by means of a single measuring receiver 2. The reciever 2 stores during an initial training phase for enough spots in the area 16 to protect (and perhaps also for comparison enough spots of the allowed area 15) that pattern/those patterns, which arise during radio transmissions 19, 20 from this spot/these spots. Hereby the patterns must generally be stored in respect of the frequency. This is necessary, because in a hospital the unwanted radio transmissions 19, 20 coming from devices (cellular phones in stand-by mode, notebooks and so on) can vary in a wide frequency band. By means of pattern recognition it is possible to recognise this pattern during a unallowed radio transmission 19, 20 and to determine this pattern with a certain probability to a certain spot within the area 16 to protect or within the allowed area 15. Hereby multi way receiving (indicated by the arrows 19, 20) must be dealt with. The direction is here also not a sufficient indication for the origin of the radio transmissions 19, 20, instead the pattern has to be taken into consideration.

Because of changes of the surrounding in accordance to the audience times, objects in the floors and so on the pattern recognition must act flexible, e.g. by using fuzzy techniques.

After recognizing an unallowed radio transmission 19 the responsible staff (e.g. floor nurse) can purposeful search/ask for the device after the local determination.

List of Reference Numbers

1 - front side of building
2 - reciever
3 - cell
4 - path of signal
5 - path of signal
6 - unallowed radio transmission in cell
7 - allowed radio transmission outside the cell
8 - obstacle
9 - reciever
10 - rows of seats
11 - fuselage
12 - path of signal
13 - seat
14 - determined position/area
15 - area with allowed radio transmission
16 - area with unallowed radio transmission
17 - emitter
18 - emitter
19 - path of signal
20 - path of signal